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Review Article

Effectiveness of mobile application-based perinatal interventions in improving parenting outcomes: A systematic review

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ABSTRACT

Objective: Parents face many challenges during the perinatal period and are at risk for mental health issues, especially during the current coronavirus (COVID-19) pandemic. Mobile application-based interventions can help parents to improve their psychosocial well-being in a convenient and accessible manner. This review aims to examine the effectiveness of mobile application-based perinatal interventions in improving parenting self-efficacy, anxiety, and depression (primary outcomes), as well as stress, social support, and parent-child bonding (secondary outcomes) among parents.

Methods: Seven electronic databases (PubMed, Embase, CINAHL, PsycINFO, Web of Science, Scopus, and ProQuest Thesis and Dissertations) were searched from their respective inception dates until August 2021. The Cochrane Risk of Bias-2 tool was used to conduct quality appraisals. Results were narratively synthesized due to the high heterogeneity of intervention and participant types.

Findings: A total of 6164 articles were retrieved from the seven electronic databases and citation searching. After excluding duplicate records and irrelevant titles/abstracts, 105 full texts were examined. Full-text screening excluded another 93 articles, leaving 12 included studies in this review. All studies were rated as having some concerns or a high overall risk of bias. Mobile application-based interventions were found to be feasible and promising in improving parents' overall well-being post-intervention during the perinatal period. Further research would be needed to determine their long-term effects.

Key conclusions and implications for practice: Parental well-being was shown to improve using the following intervention components: educational resources on perinatal and infant care, psychotherapy, and support from peers and healthcare professionals. Hence, future interventions could aim to include these components and evaluate all inter-related parenting outcomes (parenting self-efficacy, stress, anxiety, depression, social support, and parent-child bonding). Parents could be provided with experiential learning exposure by using computer animations and virtual reality. Future research could be conducted on more fathers and parents from varied geographical regions.

Introduction

Parents face numerous challenges during the perinatal period, putting them at risk for psychological problems (Vismara et al., 2016). Recent systematic reviews reported that a significant portion of parents develops perinatal depression and anxiety (Cameron et al., 2016; Dennis et al., 2017; Leiferman et al., 2021; Woody et al., 2017). As both anxiety and depression have bidirectional relationships with stress (Chen et al., 2017; Kinser et al., 2012), high perinatal stress levels among parents are also common (Vismara et al., 2016). Poor parental mental health can cause long-term detrimental effects on their children's cognitive, behavioral and physical health (Gentile and Fusco, 2017; Slomian et al., 2019), and hence needs to be addressed.

As mobile applications are exceptionally suited to deliver healthcare in a quick, feasible, convenient, and accessible manner to many individuals concurrently (Jusoh, 2017; Ngai and Chan, 2020; Osma et al., 2016), the World Health Organization has been encouraging the use of mobile applications to promote self-care (World Health Organization, 2013). A mobile application is a type of application software designed to run on a mobile device (e.g. mobile phone, tablet) and aims to provide users with specific functions (e.g. games, maps, calculator) (Magenest, 2021). As the functions of mobile applications can be tailored to address their users' specific needs, many researchers have been developing specially designed mobile applications to support people with various medical conditions: diabetes mellitus, hypertension, cardiovascular diseases, asthma, and cancer (Debon et al., 2019; Jongerius et al.,

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2019). Studies have also reported that explicitly designed maternity and/or parenting mobile applications can provide parents with various useful resources such as educational materials, peer and professional support, and mental health programs (Cuijpers et al., 2012; Khademian et al., 2020; Shorey et al., 2017; Thomas and Lupton, 2016). Hence, researchers have been exploring the use of mobile application-based interventions to improve parents' perinatal well-being (Birney et al., 2016; Ngai and Chan, 2020).

According to Bandura's self-efficacy theory, parenting self-efficacy refers to parents' belief in their ability to successfully care for their child (Bandura, 1977; de Montigny and Lacharité, 2005), and it has been recognised as an important determining factor of a successful parenting experience (Shorey et al., 2019). High parenting self-efficacy has shown to be a protective factor against perinatal depression and anxiety among parents (Albanese et al., 2019). Moreover, parents with high parenting self-efficacy and good emotional well-being (low depression and anxiety) tend to have children with better health outcomes (Albanese et al., 2019; Biehle and Mickelson, 2011; Jones and Prinz, 2005; Sanders and Woolley, 2005). Considering the effects that parenting self-efficacy, depression and anxiety have on parents and their children, these three interrelated factors should be closely examined among parents during the perinatal period. Moreover, Bowlby's theory of attachment posits that parenting self-efficacy, social support and parental mental well-being (stress, anxiety, depression) contribute to a strong early bond between parents and their children (Bowlby, 1969). Quality parent-child bonds can have profound positive effects on children's future cognitive, social, and emotional development (Leclère et al., 2014; Winston and Chicot, 2016; Wright et al., 2015). Since parents' parenting self-efficacy, depression, and anxiety share ties with their stress levels, sense of social support, and parent-child bonding, these six outcomes should be examined simultaneously to evaluate parental perinatal well-being holistically.

The 11 available reviews that investigated the effectiveness of using mobile phones to deliver perinatal interventions only focused on maternal outcomes (Chan and Chen, 2019; Colaci et al., 2016; Daly et al., 2018; Dol et al., 2020; Feroz et al., 2017; Hussain-Shamsy et al., 2020; Hussain et al., 2020; Lau et al., 2021; Nair et al., 2018; Sondaal et al., 2016; Zhou et al., 2020), and neglected to examine paternal outcomes which could also significantly affect their children's health. Five reviews restricted their scope according to the income statuses of countries and hence could not obtain a global view of perinatal interventions that utilized mobile phones (Colaci et al., 2016; Dol et al., 2020; Feroz et al., 2017; Hussain et al., 2020; Sondaal et al., 2016), while another five reviews did not focus on the use of mobile applications and could not provide specific insights regarding the effectiveness of mobile application-based perinatal interventions (Chan and Chen, 2019; Hussain-Shamsy et al., 2020; Lau et al., 2021; Nair et al., 2018; Zhou et al., 2020). While the remaining study focused on mobile application-based perinatal interventions for mothers globally, it examined limited outcomes (Daly et al., 2018); the study only examined outcomes related to maternal knowledge or behaviour during pregnancy and failed to examine mothers' parenting self-efficacy, psychological well-being, social support, and parent-child bonding. As no available review has examined the effect of mobile application-based perinatal interventions on parents' inter-related parenting outcomes of parenting self-efficacy, psychological well-being, social support, and parent-child bonding, this current review will seek to address this research gap.

Therefore, this review aims to consolidate the available evidence regarding the effectiveness of mobile application-based perinatal interventions in improving parenting self-efficacy, anxiety, and depression (primary outcomes), as well as stress, social support, and parent-child bonding (secondary outcomes) among parents. This review questions how effective mobile application-based perinatal interventions are at increasing parenting self-efficacy, social support, and parent-child bonding, as well as decreasing depression, anxiety, and stress at immediate post-intervention and follow-time point sets.

Methods

This systematic review observed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). A protocol has been registered on the PROSPERO website (XX blinded for review).

Eligibility criteria

Included studies must fulfil the criteria outlined in all the following sections: population, intervention, comparator, outcomes, study design, as well as language, and publication status. Conversely, studies that fail to fulfil the criteria of at least one of the six sections were excluded.

Population

Adult mothers, fathers, and/or partners aged 18 years and above (United Nations, 2021) during the perinatal period were included. The perinatal period refers to the duration from conception to one-year postpartum as parents are more susceptible to mental health problems during this period (Muzik and Borovska, 2010). Parents who had undergone an abortion, miscarriage, or stillbirth were excluded as they may require interventions specially tailored to their special psychological needs.

Intervention

Mobile application-based perinatal interventions that only involve the use of explicitly designed maternity and/or parenting mobile applications were included, while interventions that utilized general mobile applications which are not designed for maternity and/or parenting purposes (e.g. WhatsApp) were excluded. Interventions involving the use of mobile applications together with other non-face-to-face components such as phone calls were included while interventions involving face-to-face contact were excluded. Interventions that involved text messaging, phone calls, video calls, or voice messages only were excluded. Other technology-based interventions that do not involve mobile applications such as websites were also excluded. Interventions that involve formal therapy sessions conducted by healthcare professionals using mobile applications were excluded as this review does not seek to examine the delivery methods of formal therapy.

Comparator

Studies with any type of control group that did not use mobile applications to deliver perinatal care were included.

Outcomes

This review has three primary outcomes (parenting self-efficacy, anxiety, and depression) and three secondary outcomes (stress, social support, and parent-child bonding). Studies were included if they had assessed pre- and post-intervention measurements for at least one of the six outcomes. The immediate post-intervention scores of the primary outcomes were of primary interest while any follow-up measurements related to them were regarded secondarily. All outcomes could either be self-reported by parents or assessed by clinicians/research staff using any data collection measures/tools as reported by the primary authors.

Study design

Only randomised controlled trials (RCTs), cluster RCTs, and controlled clinical trials (CCTs) were included as RCTs are the recommended study design to examine causality (Hariton and Locascio, 2018), cluster RCTs can limit the cross-contamination of intervention effects between existing groups (Weijer et al., 2011), and CCTs can allow studies to be conducted in natural settings and serve as a good substitute when randomisation is impractical (Jackson, 2012). Other experimental study designs without a control group or pre- and post-intervention measurements were excluded because they could not assess the intervention's effect as accurately as RCTs, cluster RCTs, and CCTs.

Language and publication status

Only English language peer-reviewed published journal articles and grey literature such as unpublished dissertations and conference papers with full texts were included. Studies in abstract format only (conference/poster abstracts and studies without available full text) were excluded as limited information in the abstracts may not provide all the relevant details needed for the data extraction, appraisal, and synthesis in a systematic review.

Study selection

Seven electronic databases (PubMed, Embase, CINAHL, PsycINFO, Web of Science, Scopus, and ProQuest Thesis and Dissertations) were searched from their respective inception dates of databases to August 2021. The bibliographies of relevant reviews and included articles were reviewed and backward searching was conducted to identify additional studies. Authors were contacted to obtain full texts of potentially relevant but inaccessible studies and if the full texts could not be obtained (authors did not reply to the request for full texts), the studies were excluded. The Endnote Version X9 was used to manage the search results and remove duplicates. Titles and abstracts of all the studies were screened against the eligibility criteria. The full texts of selected studies were further scrutinised to ascertain their inclusion status. Two independent reviewers (J.C. and S.S) conducted the entire screening process and discussions were held after each stage of the screening process (e.g., after the title and abstract screening, and after full-text screening) to resolve disagreements. Search strategies for all databases were developed after consulting an experienced medical librarian and are presented in Table S1 (Supplementary file 1).

Quality appraisal

The Cochrane Risk of Bias-2 tool was used to judge the quality of all included studies in five domains: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in the measurement of the outcome and bias in the selection of the reported result (Sterne et al., 2019). Each domain was rated as 'Low', 'High', or 'Some concerns' (Sterne et al., 2019). The overall bias for each study was decided by the worst score it received in any domain (Sterne et al., 2019). Two independent reviewers (J.C. and S.S) conducted the quality appraisal process and discrepancies were discussed until a consensus was reached.

Data extraction and synthesis

A data extraction form was used to extract the following pertinent characteristics from the included studies: sample characteristics, study design, intervention content and duration, the theory used during intervention development, follow-up measurements, attrition, and outcomes measured. Data extraction was conducted by two independent reviewers (J.C. and S.S) and disagreements were resolved using discussions. Since the included studies conducted a diverse range of mobile application-based perinatal interventions for different groups of parents (some were healthy parents and others were at-risk or suffering from varying medical conditions), it was inappropriate to conduct a meta-analysis. Therefore, this review's results were summarized narratively.

Results

Search outcomes

The search from the seven listed electronic databases and citation searching yielded 6164 articles. After eliminating 3059 duplicates and 3000 irrelevant titles and abstracts due to reasons such as having the wrong study design and being non-English papers, 105 full texts were examined. After closely examining the full texts, 93 articles were excluded, leaving 12 articles to be included in this review. The search outcomes are shown in the PRISMA flow diagram (Figure 1).

Characteristics of included studies

The 12 studies consisted of three CCTs (Baumel et al., 2018; Kim et al., 2021; Prasad, 2018) and nine RCTs. They were conducted in seven different countries – Hong Kong ($n = 1$), Singapore ($n = 2$), South Korea ($n = 1$), Iran ($n = 1$), Turkey ($n = 1$), Australia ($n = 2$) and United States ($n = 4$). Different groups of parents were included: antenatal mothers ($n = 2$), postnatal mothers ($n = 7$), postnatal parents ($n = 2$), and parents across the perinatal period ($n = 1$). Parents with or without health conditions were recruited: suffering from or at risk for depression ($n = 5$), having infants admitted to neonatal intensive care unit ($n = 1$), prior history of gestational diabetes ($n = 1$), and healthy parents with healthy infants ($n = 5$). Many mobile-based interventions provided educational material in the form of readings, videos, and audio files to increase parents' knowledge of perinatal maternal care and infant care, as well as a platform for parents to seek advice from healthcare professionals. Some mobile-based interventions organized peer support groups for participants to share their own experiences (Sawyer et al., 2019; Shorey et al., 2017, 2019; Teychenne et al., 2021) while one study connected participants to trained peer volunteers with prior history of perinatal mood disorders (Baumel et al., 2018). Moreover, some mobile-based interventions provided self-guided therapy modules based on the principles of cognitive behavioural therapy (Jannati et al., 2020), or mindfulness and acceptance commitment therapy (Baumel et al., 2018; Prasad, 2018). Two interventions encouraged participants to exercise by using virtual reality technology (Kim et al., 2021) or by supplying them with free home exercise equipment in conjunction with a mobile application (Teychenne et al., 2021). One study conducted a game based on the principles of Attention Bias Modification Training (ABMT) which aimed to systematically focus one's attention away from the threat the o redirection of threat bias (Dennis-Tiwary et al., 2017). Nine studies developed interventions that were guided by theories or models. The six review outcomes were reported by various included studies: parenting self-efficacy ($n = 4$), anxiety ($n = 6$), depression ($n = 10$), stress ($n = 3$), social support ($n = 2$) and parent-child bonding ($n = 2$). The characteristics of the included studies and findings regarding the review outcomes are summarised in Tables 1 and S2 (Supplementary file 1) respectively.

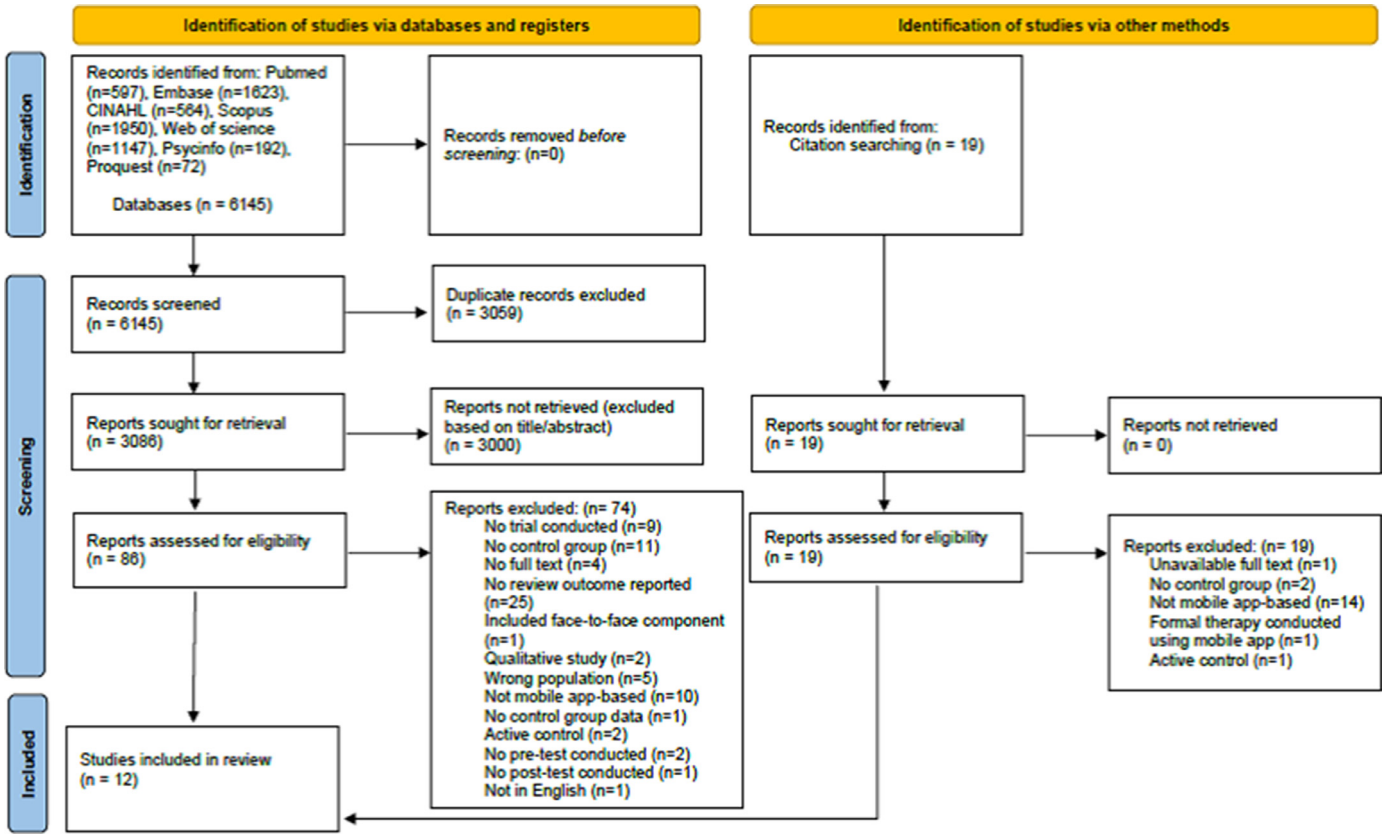

Fig. 1. PRISMA flow diagram.

Quality appraisal

The Cochrane's Risk of Bias-2 tool (Sterne et al., 2019) was used to appraise the quality of all included studies. The overall bias was rated as some concern for two studies (Jannati et al., 2020; Sawyer et al., 2019), and high risk for the remaining studies. The inter-rater agreement between both reviewers was roughly 93% and the Cohen's kappa value was 0.91. The ratings for each study are shown in Table 2 .

Parenting self-efficacy

Parenting self-efficacy was assessed by four included studies (Garfield et al., 2016; Sawyer et al., 2019; Shorey et al., 2017; Shorey et al., 2019) using three different self-reported scales – Parenting efficacy scale, Parenting stress index-competence subscale (PSI-C) and Parenting sense of competence scale (PSCS). One of the studies used both PSI-C and PSCS to assess participants' parenting self-efficacy (Sawyer et al., 2019). Two studies reported a significant increase in parenting self-efficacy scores in the intervention group from baseline compared to their respective control groups at post-intervention (Shorey et al., 2017, 2019). The remaining two studies reported no significant difference in parenting self-efficacy scores at post-intervention between the intervention and control groups (Garfield et al., 2016; Sawyer et al., 2019). After accounting for mean application usage, Garfield et al. (2016) reported a significant increase in parenting self-efficacy scores in the intervention group compared to the control group. A follow-up assessment conducted by Shorey et al. (2019) reported a sustained significant increase in parenting self-efficacy scores for the intervention group from baseline at two-months follow-up while Sawyer et al. (2019) reported no difference in scores between the two groups at four-months follow-up.

Anxiety

Six studies assessed parents' anxiety (Baumel et al., 2018; Chan et al., 2019; Dennis-Tiwary et al., 2017; Koçak et al., 2021; Shorey et al., 2019; Teychenne et al., 2021) using five different self-reported scales: State-Trait Anxiety Inventory, Beck Anxiety Inventory, Generalised Anxiety Disorder scale, Hamilton Anxiety Scale (HAM-A) and the Depression, Anxiety, and stress scale (DASS) anxiety subscale. One study used both the HAM-A and the DASS anxiety subscale to measure participants' anxiety (Dennis-Tiwary et al., 2017). Of the six studies, only two studies reported a significant reduction in participants' anxiety levels (Dennis-Tiwary et al., 2017; Shorey et al., 2019). Although Dennis-Tiwary et al. (2017) reported no significant change in anxiety scores from baseline for both the intervention and control groups post-intervention, the study noted that individuals in the intervention group showed less early visual processing of threat at baseline and reported significantly lower anxiety scores at post-intervention. On the other hand, Shorey et al. (2019) reported a significant decrease in anxiety scores from baseline for the intervention group compared to the control group after adjusting for covariates at post-intervention and without any adjustment at two-months follow-up. The remaining four studies either reported no significant difference in the anxiety levels for both groups at post-intervention (Chan et al., 2019; Koçak et al., 2021) or no evidence of the intervention's effect on participants' anxiety levels (Baumel et al., 2018; Teychenne et al., 2021).

Depression

Depression was assessed by 10 studies (Baumel et al., 2018; Chan et al., 2019; Dennis-Tiwary et al., 2017; Jannati et al., 2020; Koçak et al., 2021; Prasad, 2018; Sawyer et al., 2019; Shorey et al.,

Table 1
Characteristics of included studies.

Study/ Country	Research Design/ Study arms	Sample characteristics	Mobile application-based intervention content and components	Intervention duration/ theory used (Follow-up)	Attrition rate	Review outcome(s) reported: 1.Parenting self-efficacy 2.Anxiety 3.Depression 4.Stress 5.Social support 6.Parent-child bonding
Baumel et al., 2018 US	2 arm CCT 1.7Cups mobile app 2.Standard care	39 postnatal mothers clinically diagnosed with postpartum depression	-connect with trained peer volunteers with history of perinatal mood disorder for support (peers undergo online training) -chat rooms moderated by peer volunteers -personalised growth path to provide a step-based path to therapeutic activities and information (gratitude exercises, psychoeducation, acceptance and commitment therapy) -audio-based mindfulness exercises	30 days Peer support framework (No follow-up)	Post-test I: 15% C: 10.5%	1.No 2.Yes 3.Yes 4.No 5.No 6.No
Chan et al., 2019 Hong Kong	2 arm RCT 1.iParent mobile app 2.Standard care	660 antenatal first-time mothers with less than 24 gestation weeks remaining	-articles on nutrition, infant care, vaccinations -videos on delivery process -Q&A platform (managed by obstetricians)	Around 28 weeks (until 1 month postpartum) No theory (No follow-up)	Post-test I: 33.9% C: 31.8%	1.No 2.Yes 3.Yes 4.Yes 5.No 6.No
Dennis-Tiwary et al., 2017 US	2 arm RCT 1.ABMT mobile app 2.Placebo mobile app	33 antenatal mothers between 19-29 gestational weeks	Play game for 10 mins each day for 4 days per week.	4 weeks (ABMT) (No follow-up)	Post-test I+C: 12.12%	1.No 2.Yes 3.Yes 4.Yes 5.No 6.No
Garfield et al., 2016 US	2 arm RCT 1.NICU-2-Home mobile app 2.Standard care	90 postnatal parents of very low birth weight infants in NICU	-self guiding discharge checklist (keep track of infant's medical information) -curated multimedia educational information on NICU infant care -app to track activities of daily living -synchronised updates of parents' current mood	4 weeks Self-efficacy theory (No follow-up)	Post-test I: 26.1% C: 29.5%	1.Yes 2.No 3.No 4.No 5.No 6.No
Jannati et al., 2020 Iran	2 arm RCT 1.Happy Mom mobile app 2.Standard care	78 postnatal mothers with depression (score ≥13 on EPDS and diagnosed by a psychologist)	8 lessons of linear progression -introduction to the program and postpartum depression -goal setting -emotional recognition -noticing thoughts -thought challenging -problem-solving -improving social skills -relapse prevention	8 weeks Cognitive behavioral theory (No follow-up)	Post-test I: 2.6% C: 5.1%	1.No 2.No 3.Yes 4.No 5.No 6.No
Kim et al., 2021 South Korea	2 arm CCT 1.Mobile VR program app 2.Standard care	128 postnatal mothers who gave birth after being diagnosed with gestational diabetes	-exercise program (123 types to choose from) -diet/nutrition program to record dietary intake -laughter therapy for stress relief (18 types available) -neonatal first aid program (vomiting, nasal obstruction, colic, cramps, fever, hiccups)	12 weeks No theory (No follow-up)	Post-test I: 12.5% C: 3.1%	1.No 2.No 3.No 4.Yes 5.No 6.No
Kocak et al., 2021 Turkey	2 arm RCT 1.BebekveBiz mobile app 2.Standard care	124 postnatal mothers who gave birth to healthy single newborns	-educational material (infant care, mother care, breast milk, breastfeeding, vaccination) -motivational messages -support service to communicate with a researcher for advice	6 weeks No theory (No follow-up)	Post-test I: 19.4% C: 22.6%	1.No 2.Yes 3.Yes 4.No 5.No 6.No
Prasad, 2018 US	2 arm CCT 1.VeedaMom mobile app 2. State-provided resource booklet	62 postnatal mothers with one/two children and EPDS score ≥ 10	-track emotional well-being -mindfulness and meditation exercises -psychoeducational videos on acceptance commitment therapy and dialectical behavioural therapy -music for relaxation -suggestions to contact friends, family and healthcare providers -journal for self-expression through voice recording or typing -post pictures on social media	3 weeks Mindfulness-based, acceptance commitment therapy and dialectical behavioural therapy (No follow-up)	Post-test I: 28.1% C: 33.3%	1.No 2.No 3.Yes 4.No 5.No (No pre-test conducted for social support, hence outcome not included in the review 6.No

(*continued on next page*)

Table 1 (*continued*)

Sawyer et al., 2019 Australia	2 arm RCT 1.eMums Plus mobile app 2.Standard care	133 postnatal mothers with EPDS score ≥7 and at least 1 self-reported parenting problem	Nurse-led online group intervention (20 mothers per group) -chat room for mothers to discuss among themselves and with nurse -resources (educational articles on activities on parenting and emotional health) -timeline (track child development milestones and health reminders to provide infant age-appropriate guidance) -mood tracker for maternal and infant moods	4 months Cognitive behavioural theory and attachment theory (4 months follow-up)	Post-test I: 14.3% C: 4.9% 4 months follow-up I: 21.4% C: 4.9%	1.Yes 2.No 3.Yes 4.No 5.No 6.Yes
Shorey et al., 2019 Singapore	2 arm RCT 1.SEPP mobile app 2.Standard care	236 antenatal parents without pre-existing medical conditions who had a low-risk singleton pregnancy at > 28 gestational weeks (only heterosexual couples)	-30min telephone-based antenatal educational session -60min telephone-based immediate postnatal educational session Mobile app -educational materials on postpartum care, infant care, parental bonding, emotional challenges -discussion forum Q&A (managed by a trained midwife) -a discussion forum for parents to share experiences	4 weeks postpartum Self-efficacy theory and Bowlby's theory of attachment (2 months follow-up)	Post-test I: 20.3% C: 15.3% 4 months follow-up I: 25.4% C: 16.9%	1.Yes 2.Yes 3.Yes 4.No 5.Yes 6.Yes
Shorey et al., 2017 Singapore	2 arm RCT 1.Home-but not Alone mobile app 2.Standard care	125 postnatal parents without pre-existing medical conditions who gave birth to healthy newborns (only heterosexual couples)	-push notifications to provide timely information -educational content (articles and videos on postpartum care and infant care) -audio files (for mothers with restrictions to read during confinement) -asynchronous communication with healthcare providers and other participants	4 weeks Self-efficacy theory (No follow-up)	Post-test I: 16.7% C: 12.9%	1.Yes 2.No 3.Yes 4.No 5.Yes 6.No
Teychenne et al., 2021 Australia	2 arm RCT 1.Mums of the move intervention program 2.Standard care and waitlist control	62 postnatal mothers at 3-9 months postpartum with EPDS score ≥ 10 and insufficiently active (do not engage in 150mins of moderate intensity physical activity per week)	-provide home exercise equipment (either treadmill or stationary bicycle) -logbook for goal setting and self-monitoring -an online forum for social support -mobile app to provide motivational and informational material	12 weeks Social-ecological model (No follow-up)	Post-test depression I: 3.1% C: 16.7% Post-test anxiety I: 9.4% C: 33.3%	1.No 2.Yes 3.Yes 4.No 5.No 6.No

Note.
ABMT: Attention Bias Modification Training; C: Control; CCT: Controlled Clinical Trial; EPDS: Edinburgh Postnatal Depression Scale; I: Intervention; NICU: Neonatal Intensive Care Unit; Q&A: Question and answer; RCT: Randomised Controlled Trial; SEPP: Supportive educational parenting program; US: United States; VR: Virtual reality

Table 2
Risk of bias assessments for included studies.

Study	Domain 1	Domain 2a	Domain 2b	Domain 3	Domain 4	Domain 5	Overall bias
Baumel et al. (2018)	High risk	Low risk	Low risk	Low risk	Some concerns	High risk	High risk
Chan et al. (2019)	Low risk	Low risk	Some concerns	Low risk	Some concerns	High risk	High risk
Dennis-Tiwary et al. (2017)	Low risk	Some concerns	Low risk	Low risk	Low risk	High risk	High risk
Garfield et al. (2016)	Low risk	Low risk	Some concerns	Low risk	Some concerns	High risk	High risk
Jannati et al. (2020)	Low risk	Some concerns	Low risk	Low risk	Some concerns	Low risk	Some concerns
Kim et al. (2021)	High risk	Some concerns	Low risk	Low risk	Some concerns	Low risk	High risk
Kocak et al. (2021)	Some concern	High risk	High risk	Low risk	Some concerns	Low risk	High risk
Prasad, 2018)	High risk	High risk	High risk	Low risk	High risk	Low risk	High risk
Sawyer et al. (2019)	Some concerns	Low risk	Low risk	Low risk	Some concerns	Low risk	Some concerns
Shorey et al. (2019)	Low risk	Low risk	High risk	Low risk	Some concerns	High risk	High risk
Shorey et al. (2017)	Low risk	Low risk	Low risk	Low risk	Some concerns	High risk	High risk
Teychenne et al. (2021)	Low risk	High risk	High risk	Low risk	Some concerns	Low risk	High risk

Note.
Domain 1: Risk of bias arising from the randomization process
Domain 2a: Risk of bias due to deviations from the intended interventions (effect of assignment to intervention)
Domain 2b: Risk of bias due to deviations from the intended interventions (effect of adhering to intervention)
Domain 3: Risk of bias due to missing outcome data
Domain 4: Risk of bias in measurement of the outcome
Domain 5: Risk of bias in selection of the reported result

2017, 2019; Teychenne et al., 2021) using three different self-reported scales – Edinburgh Postnatal Depression Scale (EPDS), Beck Depression Inventory-II (BDI-II), and the DASS depression subscale. The EPDS was the most frequently used scale; nine studies used it to assess depressive symptoms. One study used both the EPDS and the BDI-II to measure participants' depression (Baumel et al., 2018). Five studies reported a significant decrease in depression scores after the intervention (Chan et al., 2019; Jannati et al., 2020; Prasad, 2018; Sawyer et al., 2019; Shorey et al., 2019). They either reported significantly lower depression scores compared to the control group at post-intervention (Chan et al., 2019; Sawyer et al., 2019) and four-month follow-up (Sawyer et al., 2019) or reported a significant decrease in depression scores from baseline for the intervention group compared to the control group at post-intervention (Jannati et al., 2020; Prasad, 2018; Shorey et al., 2019) and two-months follow-up (Shorey et al., 2019). The remaining five studies reported no significant differences in the depression scores of both groups at post-intervention (Baumel et al., 2018; Dennis-Tiwary et al., 2017; Koçak et al., 2021; Shorey et al., 2017; Teychenne et al., 2021).

Stress

Three studies measured self-reported stress levels using the DASS stress subscale (Chan et al., 2019; Dennis-Tiwary et al., 2017), or the Parenting Stress scale (Kim et al., 2021). Objective assessments of stress were made by measuring the salivary cortisol levels of participants in Dennis-Tiwary et al. (2017). At post-intervention, two studies reported no significant difference between the stress scores of both intervention and control groups (Chan et al., 2019; Kim et al., 2021), and one study reported no significant change in the scores of both groups from baseline (Dennis-Tiwary et al., 2017). Dennis-Tiwary et al. (2017) also reported that the amount of salivary cortisol secretion of the intervention group was significantly lesser than that of the control group post-intervention. No follow-up measurements were conducted for stress.

Social support

Social support was assessed by two included studies via the Perceived Social Support for Parenting scale (Shorey et al., 2017; Shorey et al., 2019). Both studies reported significantly higher scores for perceived social support in the intervention group from baseline compared to their respective control groups at post-intervention (Shorey et al., 2017; Shorey et al., 2019) and two months follow-up for Shorey et al. (2019).

Parent-child bonding

Two studies assessed self-reported parent-child bonding using the Parent-to-Infant Bonding Questionnaire (Shorey et al., 2019) or the Parenting Stress Index-Attachment subscale (Sawyer et al., 2019). An objective assessment of the quality of mother-child interactions was carried out by trained research assistants by Sawyer et al. (2019). The research assistants analysed a short video recording of mothers teaching their children an age-appropriate skill and rated the mother-child interactions using the Nursing Child Assessment Satellite Training scale (Sawyer et al., 2019). Results from the self-reported outcomes indicate significantly better parent-child bonding scores in the intervention group compared to the control group at post-intervention and at their respective follow-up time points (Sawyer et al., 2019; Shorey et al., 2019). The objective assessment conducted by research assistants in Sawyer et al. (2019) at a four-months follow-up indicates no difference in parent-child bonding between the intervention and control groups. No objective assessment was made immediately post-intervention.

Maternal versus paternal outcomes

Only three included studies assessed the effectiveness of mobile application-based interventions on both maternal and paternal parenting outcomes (Garfield et al., 2016; Shorey et al., 2017; Shorey et al., 2019). Garfield at el. (2016) did not conduct separate analyses for mothers and fathers while the remaining two studies conducted subgroup analyses for both parents (Shorey et al., 2017; Shorey et al., 2019). Shorey et al. (2017) reported similar results for both mothers and fathers at post-intervention (significant improvement in parenting self-efficacy and social support but not depression) while Shorey et al. (2019) noted some differences between both parents. During post-intervention, both parents reported significant increases in parenting self-efficacy, parent-child bonding, and social support, as well as decreases in depression and anxiety scores compared to their respective baseline scores (Shorey et al., 2019). At two-month follow-up, fathers reported significant improvement for all outcomes, but mothers only reported significant improvement in parent-child bonding, depression, and anxiety (Shorey et al., 2019). After doing adjustments for covariates of maternal outcomes, a significant increase was reported for an additional outcome of social support (Shorey et al., 2019).

Discussion

This review consolidated and synthesised the available literature on mobile application-based perinatal interventions in improving parenting outcomes (parenting self-efficacy, anxiety, depression, social support, and parent-child bonding) among parents. As only three out of 12 studies examined fathers, current findings are more applicable to mothers. While mothers are more susceptible to perinatal mental health problems, a significant proportion of fathers also suffer from similar problems (Cameron et al., 2016; Leiferman et al., 2021). Previous studies have established a strong association between the psychological well-being of mothers and fathers (Ansari et al., 2021); longitudinal studies reported that one's worsening depressive symptoms could result in a similar decline in one's spouse' mental health (Monin et al., 2016). As the mood of one parent can influence the mood of the other (Monin et al., 2016), future studies should conduct mobile application-based perinatal interventions for both parents to improve their mental well-being simultaneously. Moreover, with limited trials representing parents from the Middle East, Europe, and Africa, future trials need to be conducted in these regions to understand how different cultures affect parents' experience with mobile application-based interventions.

This review found that mobile application-based perinatal interventions could improve parents' parenting outcomes as some included studies reported significant improvement in parenting self-efficacy (three out of four studies), anxiety (two out of six studies), depression (five out of ten studies), stress (one out of three studies), social support (two studies) and parent-child bonding (two studies). On the other hand, a previous review reported a significant decrease in depression and mixed findings of effectiveness for parenting self-efficacy, anxiety, and social support (Dol et al., 2020). As it did not specifically examine mobile application-based interventions and only analysed mothers from high-income countries, results cannot be directly compared (Dol et al., 2020). The mobile application-based perinatal interventions evaluated in the included studies of this review were found to be feasible and viable methods of improving parents' parenting outcomes, which is encouraging as parents have had to rely more on technology-

based resources for perinatal support during the COVID-19 pandemic (Cameron et al., 2020). Recent studies have shown that many parents (especially mothers) have chosen to isolate themselves to avoid COVID-19 infection, leading them to receive insufficient perinatal support from healthcare professionals, friends, and family (Ceulemans et al., 2021; Lim et al., 2021). This puts them at higher risk of developing psychological problems during the perinatal period (Ceulemans et al., 2021; Molgora & Accordini, 2020; Thapa et al., 2020), with more mothers experiencing perinatal depressive and anxiety symptoms during the COVID-19 period compared to the pre-pandemic period (Hessami et al., 2020; Lebel et al., 2020; Suwalska et al., 2021). Therefore, researchers have advocated the use of technology such as mobile applications to support parents during the perinatal period (Cameron et al., 2020; Thapa et al., 2020), and this review's timely findings regarding the possible benefits of mobile application-based perinatal interventions lend support to this view.

Most studies that assessed parenting self-efficacy reported significant improvements. The interventions included multimedia educational resources on parenting (articles, videos, audio files), and a platform for parents to contact healthcare professionals and other parents (Garfield et al., 2016; Shorey et al., 2017; Shorey et al., 2019). According to Bandura's self-efficacy theory, these components could have helped parents to improve their parenting self-efficacy through mastery experiences (access to convenient educational materials to practice parenting skills), vicarious experiences (learning from other parents' similar experiences), and verbal persuasion (useful advice from other parents and healthcare professionals) (Bandura, 1977). The importance of education in increasing parents' parenting self-efficacy was also recognised by previous reviews (Dol et al., 2020; Liyana Amin et al., 2018). Hence, future mobile application-based interventions could continue to include educational components and assess parenting self-efficacy to further explore this association. However, such digital educational methods do not facilitate hands-on learning which may hinder parents' mastery of parenting skills (Shorey et al., 2019). While one study used virtual reality technology to teach parents about neonatal first aid, it did not assess participants' parenting self-efficacy (Kim et al., 2021). As computer animations and virtual reality technology can educate parents and provide near authentic experiences about infant care skills (Kim et al., 2021; Pinto et al., 2018), future studies could explore the effectiveness of such immersive methods more thoroughly.

Few studies reported a significant decrease in anxiety or stress scores while only five out of 10 studies reported a significant decrease in depression scores. This review found that studies that reported a significant improvement in anxiety or depression had included some form of psychotherapeutic element in their interventions such as mindfulness-based modules (Prasad, 2018), cognitive behavioural therapy (Jannati et al., 2020), and education about emotional health (Sawyer et al., 2019; Shorey et al., 2019). Similarly, a previous review also reported the effectiveness of digital psychotherapeutic perinatal interventions in improving depression, anxiety, and stress among women (Lau et al., 2021). Only two interventions that included a psychotherapeutic component reported no significant improvement in parents' psychological well-being (Baumel et al., 2018; Kim et al., 2021). The only study that reported a significant decrease in stress via less secretion of salivary cortisol conducted ABMT and more research would be required to determine this intervention's effectiveness (Dennis-Tiwary et al., 2017). Conversely, interventions without a psychological-based component had no (Koçak et al., 2021; Shorey et al., 2017; Teychenne et al., 2021) or limited (Chan et al., 2019) effectiveness in improving parents' psychological well-being. Results suggested that psychotherapy could be needed to improve parents' stress, anxiety, and depression (Koçak et al., 2021). Exercise programs, provision of non-psychological educational materials, and support from peers and healthcare professionals may be inadequate to improve parents' mental health. Therefore, future mobile application-based perinatal interventions could incorporate psychotherapeutic components to address parents' psychological needs.

The two studies that assessed social support reported a significant improvement after the intervention. Both studies provided parents with digital platforms for them to discuss their personal experiences with their peers and healthcare professionals (Shorey et al., 2017; Shorey et al., 2019). Despite the limited available data, current findings suggested that digital communication with peers and professionals via the use of mobile applications could allow parents to feel more supported. This sentiment was also previously echoed (Dol et al., 2020). As social support can protect one against poor mental health (Li et al., 2017), future interventions could promote the provision of peer and professional support for parents during the perinatal period. Moreover, since only two studies examined social support, further investigation of this outcome is needed.

Parent-child bonding was examined by two studies that reported a significant improvement after the intervention. Both studies provided educational resources on parenting, infant care, and emotional health, as well as support from peers and healthcare professionals via mobile applications (Sawyer et al., 2019; Shorey et al., 2019), suggesting that these elements helped to promote better parent-child bonding. As these components could improve parenting self-efficacy, social support, and parental mental well-being, together with parent-child bonding, current findings support Bowlby's theory of attachment which theorises links between these constructs (Bowlby, 1969). A strong parent-child relationship during infancy could have long-lasting positive effects on the child's development whereas a poor relationship could cause future behavioural and psychological problems among children (Leclère et al., 2014; Winston and Chicot, 2016). As experts and researchers have recommended providing parents with psychological support and educating them about infant care to encourage parent-child bonding (Shonkoff, 2010; Winston and Chicot, 2016), future mobile application-based interventions could incorporate these elements to benefit parents. Moreover, due to the limited data regarding parent-child bonding, further research is needed.

Only Sawyer et al. (2019) and Shorey et al. (2019) conducted follow-up assessments at four and two months respectively. Sawyer et al. (2019) reported sustained improvement in depression and parent-child bonding at four months follow-up while Shorey et al. (2019) reported sustained improvement in parenting self-efficacy, anxiety, depression, social support, and parent-child bonding at two-months follow-up. A similar lack of follow-up assessments was reported by previous reviews (Daly et al., 2018; Dol et al., 2020; Lau et al., 2021). While the currently limited data suggested the possibility of sustained positive effects of mobile application-based interventions on parents' well-being for 2-4 months, the long-term effects of these interventions require further evaluation.

Two studies conducted subgroup analysis for mothers and fathers and showed that both parents' well-being was similarly affected by mobile application-based interventions; current findings suggested that both fathers and mothers benefited from these interventions (Shorey et al., 2017; Shorey et al., 2019). However, conclusions regarding the relative effectiveness of mobile application-based interventions between mothers and fathers could not be drawn due to a lack of data. Hence, future studies would need to explore this point further.

Limitations

Ambiguous titles, abstracts, and poor indexing could have excluded other relevant studies. The inclusion of only English language papers and exclusion of <1% of non-English papers could incur potential publication bias. Although the search strategies were developed based on the expert input of medical librarians, a formal peer-review process was not conducted to assess their quality and comprehensiveness (McGowan et al., 2016). The risk of social desirability bias was present as most outcomes were self-reported by participants. The lack of studies from the Middle East, Europe, and Africa and insufficient engagement of fathers could affect current results' generalizability to parents worldwide. Since all studies were rated as having some concerns or a high overall risk of bias, the overall quality of evidence could compromise the results' validity and reliability. Lastly, due to the high heterogeneity of mobile application-based interventions and participants, results could not be statistically pooled in a meaningful manner and hence meta-analysis could not be conducted.

Implications for future research and practice

Future mobile application-based perinatal interventions could include educational resources on perinatal and infant care, some form of psychotherapy, as well as platforms for parents to interact with their peers and healthcare professionals to improve parents' parenting self-efficacy, stress, anxiety, depression, social support, and parent-child bonding. These interventions could also assess all these inter-related outcomes to obtain a holistic understanding of parents' well-being. More immersive educational methods such as computer animations and virtual reality technology could be explored to provide parents with experiential learning experiences in the safety of their homes during the pandemic. Since both mothers and fathers are vulnerable to perinatal mental health issues, future studies could recruit both parents and additional analyses could be conducted to determine any differences in the effect of mobile application-based interventions on mothers and fathers. Moreover, longer follow-up assessments could help to ascertain the sustainability of these interventions' effect on parents. Lastly, as there were limited trials representing parents from the Middle East, Europe, and Africa, more trials could be conducted in these regions to obtain a global understanding of parents' experiences during the perinatal period.

Conclusion

Overall, this review found that mobile application-based perinatal interventions were viable methods that could improve parents' well-being and provide them with much-needed support during the COVID-19 pandemic. Current findings showed that mobile application-based perinatal interventions could improve parents' parenting self-efficacy, psychological well-being, social support, and parent-child bonding post-intervention. Further investigation would be needed to examine the long-term effects of these interventions. Components of mobile application-based interventions that were shown to improve parents' overall well-being include educational resources on relevant topics, psychotherapy, and support from peers and healthcare professionals. To holistically assess the interventions' effect on parents' well-being, inter-related outcomes of parenting self-efficacy, stress, anxiety, depression, social support, and parent-child bonding could be examined. Computer animations and virtual reality technology could be considered to provide parents with more engaging digital educational experiences. Future studies could also aim to include both parents, investigate any differences between the interventions' effects on mothers and fathers, and include parents from more diverse cultures. Due to current limitations, future research is needed to confirm the findings.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.midw.2022.103457.

References

Albanese, A.M., Russo, G.R., Geller, P.A., 2019. The role of parental self-efficacy in parent and child well-being: a systematic review of associated outcomes. Child Care Health Dev. 45 (3), 333–363. doi:10.1111/cch.12661.

Ansari, N.S., Shah, J., Dennis, C.-L., Shah, P.S, 2021. Risk factors for postpartum depressive symptoms among fathers: a systematic review and meta-analysis. Acta Obstet. Gynecol. Scand. doi:10.1111/aogs.14109.

Bandura, A., 1977. Self-efficacy: Toward a unifying theory of behavioral change. Psychol. Rev. 84 (2), 191–215. doi:10.1037/0033-295X.84.2.191.

Baumel, A., Tinkelman, A., Mathur, N., Kane, J.M., 2018. Digital peer-support platform (7Cups) as an adjunct treatment for women with postpartum depression: feasibility, acceptability, and preliminary efficacy study. JMIR Mhealth Uhealth 6 (2), e38. doi:10.2196/mhealth.9482.

Biehle, S.N., Mickelson, K.D., 2011. Personal and co-parent predictors of parenting efficacy across the transition to parenthood. J. Soc. Clin. Psychol. 30 (9), 985–1010. doi:10.1521/jscp.2011.30.9.985.

Birney, A.J., Gunn, R., Russell, J.K., Ary, D.V., 2016. MoodHacker mobile web app with email for adults to self-manage mild-to-moderate depression: randomized controlled trial. JMIR Mhealth Uhealth 4 (1). doi:10.2196/mhealth.4231, e8-e8.

Bowlby, J., 1969. In: Attachment and loss, 79. Hogarth P, p. 109.

Cameron, E.E., Joyce, K.M., Delaquis, C.P., Reynolds, K., Protudjer, J.L.P., Roos, L.E., 2020. Maternal psychological distress & mental health service use during the COVID-19 pandemic. J. Affect. Disord. 276, 765–774. doi:10.1016/j.jad.2020.07.081.

Cameron, E.E., Sedov, I.D., Tomfohr-Madsen, L.M., 2016. Prevalence of paternal depression in pregnancy and the postpartum: an updated meta-analysis. J. Affect. Disord. 206, 189–203. doi:10.1016/j.jad.2016.07.044.

Ceulemans, M., Foulon, V., Ngo, E., Panchaud, A., Winterfeld, U., Pomar, L., Lambelet, V., Cleary, B., O'Shaughnessy, F., Passier, A., Richardson, J.L., Hompes, T., Nordeng, H., 2021. Mental health status of pregnant and breastfeeding women during the COVID-19 pandemic—a multinational cross-sectional study. Acta Obstet. Gynecol. Scand. 100 (7), 1219–1229. doi:10.1111/aogs.14092.

Chan, K.L., Chen, M., 2019. Effects of social media and mobile health apps on pregnancy care: meta-analysis. JMIR Mhealth Uhealth 7 (1), e11836. doi:10.2196/11836.

Chan, K.L., Leung, W.C., Tiwari, A., Or, K.L., Ip, P., 2019. Using smartphone-based psychoeducation to reduce postnatal depression among first-time mothers: randomized controlled trial. JMIR Mhealth Uhealth 7 (5), e12794. doi:10.2196/12794.

Chen, C.V., George, S.A., Liberzon, I., 2017. Stress and Anxiety Disorders. In: Pfaff, D.W., Joëls, M. (Eds.), Hormones, Brain and Behavior. Elsevier Inc, pp. 251–274.

Colaci, D., Chaudhri, S., Vasan, A., 2016. mHealth interventions in low-income countries to address maternal health: a systematic review. Ann. Glob. Health 82 (5), 922–935. doi:10.1016/j.aogh.2016.09.001.

Cuijpers, P., Beekman, A.T.F., Reynolds, C.F., 2012. Preventing depression: a global priority. JAMA 307 (10), 1033–1034. doi:10.1001/jama.2012.271.

Daly, L.M., Horey, D., Middleton, P.F., Boyle, F.M., Flenady, V., 2018. The effect of mobile app interventions on influencing healthy maternal behavior and improving perinatal health outcomes: systematic review. JMIR Mhealth Uhealth 6 (8), e10012. doi:10.2196/10012.
de Montigny, F., Lacharité, C., 2005. Perceived parental efficacy: concept analysis. J. Adv. Nurs. 49 (4), 387–396. doi:10.1111/j.1365-2648.2004.03302.x.
Debon, R., Coleone, J.D., Bellei, E.A., De Marchi, A.C.B., 2019. Mobile health applications for chronic diseases: a systematic review of features for lifestyle improvement. Diabetes Metab. Syndr. 13 (4), 2507–2512. doi:10.1016/j.dsx.2019.07.016.
Dennis-Tiwary, T.A., Denefrio, S., Gelber, S., 2017. Salutary effects of an attention bias modification mobile application on biobehavioral measures of stress and anxiety during pregnancy. Biol. Psychol. 127, 148–156. doi:10.1016/j.biopsycho.2017.05.003.
Dennis, C.L., Falah-Hassani, K., Shiri, R., 2017. Prevalence of antenatal and postnatal anxiety: systematic review and meta-analysis. Br. J. Psychiatry 210 (5), 315–323. doi:10.1192/bjp.bp.116.187179.
Dol, J., Richardson, B., Murphy, G.T., Aston, M., McMillan, D., Campbell-Yeo, M., 2020. Impact of mobile health interventions during the perinatal period on maternal psychosocial outcomes: a systematic review. JBI Evid. Synth. 18 (1), 30–55. doi:10.11124/jbisrir-d-19-00191.
Feroz, A., Perveen, S., Aftab, W., 2017. Role of mHealth applications for improving antenatal and postnatal care in low and middle income countries: a systematic review. BMC Health Serv. Res. 17 (1), 704. doi:10.1186/s12913-017-2664-7.
Garfield, C.F., Lee, Y.S., Kim, H.N., Rutsohn, J., Kahn, J.Y., Mustanski, B., Mohr, D.C., 2016. Supporting parents of premature infants transitioning from the NICU to home: a pilot randomized control trial of a smartphone application. Internet Interv. 4, 131–137. doi:10.1016/j.invent.2016.05.004.
Gentile, S., Fusco, M.L., 2017. Untreated perinatal paternal depression: effects on offspring. Psychiatry Res. 252, 325–332. doi:10.1016/j.psychres.2017.02.064.
Hariton, E., Locascio, J.J., 2018. Randomised controlled trials - the gold standard for effectiveness research: study design: randomised controlled trials. BJOG 125 (13). doi:10.1111/1471-0528.15199, 1716-1716.
Hessami, K., Romanelli, C., Chiurazzi, M., Cozzolino, M., 2020. COVID-19 pandemic and maternal mental health: a systematic review and meta-analysis. J. Matern. Fetal Neonatal Med. 1–8. doi:10.1080/14767058.2020.1843155.
Hussain-Shamsy, N., Shah, A., Vigod, S.N., Zaheer, J., Seto, E., 2020. Mobile health for perinatal depression and anxiety: scoping review. J. Med. Internet Res. 22 (4), e17011. doi:10.2196/17011.
Hussain, T., Smith, P., Yee, L.M., 2020. Mobile phone-based behavioral interventions in pregnancy to promote maternal and fetal health in high-income countries: systematic review. JMIR Mhealth Uhealth 8 (5), e15111. doi:10.2196/15111.
Jackson, S.L., 2012. Research methods and statistics: a critical thinking approach, 4th ed. Wadsworth Cengage Learning.
Jannati, N., Mazhari, S., Ahmadian, L., Mirzaee, M., 2020. Effectiveness of an app-based cognitive behavioral therapy program for postpartum depression in primary care: a randomized controlled trial. Int. J. Med. Inform. 141, 104145. doi:10.1016/j.ijmedinf.2020.104145.
Jones, T.L., Prinz, R.J., 2005. Potential roles of parental self-efficacy in parent and child adjustment: a review. Clin. Psychol. Rev. 25 (3), 341–363. doi:10.1016/j.cpr.2004.12.004.
Jongerius, C., Russo, S., Mazzocco, K., Pravettoni, G., 2019. Research-tested mobile apps for breast cancer care: systematic review. JMIR Mhealth Uhealth 7 (2), e10930. doi:10.2196/10930.
Jusoh, S., 2017. A survey on trend, opportunities and challenges of mHealth apps. Int. J. Interactive Mobile Technol. (iJIM) 11, 73. doi:10.3991/ijim.v11i6.7265.
Khademian, F., Aslani, A., Bastani, P., 2020. The effects of mobile apps on stress, anxiety, and depression: overview of systematic reviews. Int. J. Technol. Assess. Health Care 37 (1). doi:10.1017/S0266462320002093, e4-e4.
Kim, S.H., Kim, H.J., Shin, G., 2021. Self-management mobile virtual reality program for women with gestational diabetes. Int. J. Environ. Res. Public Health 18 (4), 1–12. doi:10.3390/ijerph18041539, Article 1539.
Kinser, P.A., Goehler, L.E., Taylor, A.G., 2012. How might yoga help depression? A neurobiological perspective. Explore (NY) 8 (2), 118–126. doi:10.1016/j.explore.2011.12.005.
Koçak, V., Ege, E., İyisoy, M.S., 2021. The development of the postpartum mobile support application and the effect of the application on mothers' anxiety and depression symptoms. Arch. Psychiatr. Nurs. 35 (5), 441–449. doi:10.1016/j.apnu.2021.06.009.
Lau, Y., Cheng, J.Y., Wong, S.H., Yen, K.Y., Cheng, L.J., 2021. Effectiveness of digital psychotherapeutic intervention among perinatal women: a systematic review and meta-analysis of randomized controlled trials. World J. Psychiatry 11 (4), 133–152. doi:10.5498/wjp.v11.i4.133.
Lebel, C., MacKinnon, A., Bagshawe, M., Tomfohr-Madsen, L., Giesbrecht, G., 2020. Elevated depression and anxiety symptoms among pregnant individuals during the COVID-19 pandemic. J. Affect. Disord. 277, 5–13. doi:10.1016/j.jad.2020.07.126.
Leclère, C., Viaux, S., Avril, M., Achard, C., Chetouani, M., Missonnier, S., Cohen, D., 2014. Why synchrony matters during mother-child interactions: a systematic review. PLoS One 9 (12), e113571. doi:10.1371/journal.pone.0113571.
Leiferman, J.A., Farewell, C.V., Jewell, J., Lacy, R., Walls, J., Harnke, B., Paulson, J.F., 2021. Anxiety among fathers during the prenatal and postpartum period: a meta-analysis. J. Psychosom. Obstet. Gynaecol. 42 (2), 152–161. doi:10.1080/0167482X.2021.1885025.
Li, Y., Long, Z., Cao, D., Cao, F., 2017. Social support and depression across the perinatal period: a longitudinal study. J. Clin. Nurs. 26 (17-18), 2776–2783. doi:10.1111/jocn.13817.
Lim, S., Savaglio, M., Skouteris, H., Moran, L., 2021. Mental health among postpartum women during the COVID-19 pandemic. Acta Obstet. Gynecol. Scand. 100 (8), 1537–1538. doi:10.1111/aogs.14144.
Liyana Amin, N.A., Tam, W.W.S., Shorey, S., 2018. Enhancing first-time parents' self-efficacy: a systematic review and meta-analysis of universal parent education interventions' efficacy. Int. J. Nurs. Stud. 82, 149–162. doi:10.1016/j.ijnurstu.2018.03.021.
Magenest. (2021). *Mobile application: definition, technology types and examples 2022*. magenest. Retrieved 20 July from https://magenest.com/en/mobile-application/.
McGowan, J., Sampson, M., Salzwedel, D.M., Cogo, E., Foerster, V., Lefebvre, C., 2016. PRESS peer review of electronic search strategies: 2015 guideline statement. J. Clin. Epidemiol. 75, 40–46. doi:10.1016/j.jclinepi.2016.01.021.
Molgora, S., Accordini, M., 2020. Motherhood in the time of coronavirus: the impact of the pandemic emergency on expectant and postpartum women's psychological well-being. Front. Psychol. 11. doi:10.3389/fpsyg.2020.567155, 567155-567155.
Monin, J., Doyle, M., Levy, B., Schulz, R., Fried, T., Kershaw, T., 2016. Spousal associations between frailty and depressive symptoms: longitudinal findings from the cardiovascular health study. J. Am. Geriatr. Soc. (JAGS) 64 (4), 824–830. doi:10.1111/jgs.14023.
Muzik, M., Borovska, S., 2010. Perinatal depression: implications for child mental health. Ment. Health Family Med. 7 (4), 239–247. https://pubmed.ncbi.nlm.nih.gov/22477948.
Nair, U., Armfield, N.R., Chatfield, M.D., Edirippulige, S., 2018. The effectiveness of telemedicine interventions to address maternal depression: A systematic review and meta-analysis. J. Telemed. Telecare. 24 (10), 639–650. doi:10.1177/1357633x18794332.
Ngai, F.W., Chan, P.S., 2020. Perception of family sense of coherence during parental transition: a qualitative study. J. Health Psychol. doi:10.1177/1359105320914062, 1359105320914062.
Osma, J., Barrera, A.Z., Ramphos, E., 2016. Are pregnant and postpartum women interested in health-related apps? Implications for the prevention of perinatal depression. Cyberpsychology Behav. Soc. Netw. 19 (6), 412–415. doi:10.1089/cyber.2015.0549.
Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., Moher, D., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372, n71. doi:10.1136/bmj.n71.
Pinto, T.D.R.C., Castro, D.S.d., Bringuente, M.E.d.O., Sant'Anna, H.C., Souza, T.V., Primo, C.C., 2018. Educational animation about home care with premature newborn infants. Rev. Bras. Enferm. 71 (suppl 4), 1604–1610. doi:10.1590/0034-7167-2017-0401.
Prasad, V., 2018. Efficacy of an electronic application to moderate symptoms of postpartum depression and improve postpartum well-being: a pilot study. [Educational Psychology 3500]. Diss. Abstr. Int. Sect. A Humanit. Soc. Sci. 79 (10-A(E)) No-Specified.
Sanders, M.R., Woolley, M.L., 2005. The relationship between maternal self-efficacy and parenting practices: implications for parent training. Child Care Health Dev. 31 (1), 65–73. doi:10.1111/j.1365-2214.2005.00487.x.
Sawyer, A., Kaim, A., Le, H.N., McDonald, D., Mittinty, M., Lynch, J., Sawyer, M., 2019. The effectiveness of an app-based nurse-moderated program for new mothers with depression and parenting problems (eMums Plus): pragmatic randomized controlled trial. J. Med. Internet Res. 21 (6), e13689. doi:10.2196/13689.
Shonkoff, J.P., 2010. Building a new biodevelopmental framework to guide the future of early childhood policy. Child Dev. 81 (1), 357–367. doi:10.1111/j.1467-8624.2009.01399.x.
Shorey, S., Lau, Y., Dennis, C.L., Chan, Y.S., Tam, W.W.S., Chan, Y.H., 2017. A randomized-controlled trial to examine the effectiveness of the 'Home-but not Alone' mobile-health application educational programme on parental outcomes. J. Adv. Nurs. 73 (9), 2103–2117. doi:10.1111/jan.13293.
Shorey, S., Ng, Y.P.M., Ng, E.D., Siew, A.L., Mörelius, E., Yoong, J., Gandhi, M., 2019. Effectiveness of a technology-based supportive educational parenting program on parental outcomes (Part 1): randomized controlled trial. J. Med. Internet Res. 21 (2), e10816. doi:10.2196/10816.
Slomian, J., Honvo, G., Emonts, P., Reginster, J.-Y., Bruyère, O., 2019. Consequences of maternal postpartum depression: a systematic review of maternal and infant outcomes. Women's Health 15, 1745506519844044. doi:10.1177/1745506519844044.
Sondaal, S.F., Browne, J.L., Amoakoh-Coleman, M., Borgstein, A., Miltenburg, A.S., Verwijs, M., Klipstein-Grobusch, K., 2016. Assessing the effect of mhealth interventions in improving maternal and neonatal care in low- and middle-income countries: a systematic review. PLoS One 11 (5), e0154664. doi:10.1371/journal.pone.0154664.
Sterne, J.A.C., Savović, J., Page, M.J., Elbers, R.G., Blencowe, N.S., Boutron, I., Cates, C.J., Cheng, H.Y., Corbett, M.S., Eldridge, S.M., Emberson, J.R., Hernán, M.A., Hopewell, S., Hróbjartsson, A., Junqueira, D.R., Jüni, P., Kirkham, J.J., Lasserson, T., Li, T., McAleenan, A., Reeves, B.C., Shepperd, S., Shrier, I., Stewart, L.A., Tilling, K., White, I.R., Whiting, P.F., Higgins, J.P.T., 2019. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 366, l4898. doi:10.1136/bmj.l4898.
Suwalska, J., Napierała, M., Bogdański, P., Łojko, D., Wszołek, K., Suchowiak, S., Suwalska, A., 2021. Perinatal mental health during COVID-19 pandemic: an integrative review and implications for clinical practice. J. Clin. Med. 10 (11), 2406. doi:10.3390/jcm10112406.

Teychenne, M., Abbott, G., Stephens, L.D., Opie, R.S., Olander, E.K., Brennan, L., van der Pligt, P., Apostolopoulos, M., Ball, K., 2021. Mums on the move: a pilot randomised controlled trial of a home-based physical activity intervention for mothers at risk of postnatal depression. Midwifery 93, 102898. doi:10.1016/j.midw.2020.102898.

Thapa, S.B., Mainali, A., Schwank, S.E., Acharya, G., 2020. Maternal mental health in the time of the COVID-19 pandemic. Acta Obstet. Gynecol. Scand. 99 (7), 817–818. doi:10.1111/aogs.13894.

Thomas, G.M., Lupton, D., 2016. Threats and thrills: pregnancy apps, risk and consumption. Health Risk Soc. 17 (7-8), 495–509. doi:10.1080/13698575.2015.1127333.

United Nations, 2021. Youth. United Nations Retrieved 5 March 2021 from.

Vismara, L., Rollè, L., Agostini, F., Sechi, C., Fenaroli, V., Molgora, S., Neri, E., Prino, L.E., Odorisio, F., Trovato, A., Polizzi, C., Brustia, P., Lucarelli, L., Monti, F., Saita, E., Tambelli, R., 2016. Perinatal parenting stress, anxiety, and depression outcomes in first-time mothers and fathers: a 3- to 6-months postpartum follow-up study. Front. Psychol. 7. doi:10.3389/fpsyg.2016.00938, 938-938.

Weijer, C., Grimshaw, J.M., Taljaard, M., Binik, A., Boruch, R., Brehaut, J.C., Donner, A., Eccles, M.P., Gallo, A., McRae, A.D., Saginur, R., Zwarenstein, M., 2011. Ethical issues posed by cluster randomized trials in health research. Trials 12 (1). doi:10.1186/1745-6215-12-100, 100-100.

Winston, R., Chicot, R., 2016. The importance of early bonding on the long-term mental health and resilience of children. Lond. J. Prim. Care 8 (1), 12–14. doi:10.1080/17571472.2015.1133012.

Woody, C.A., Ferrari, A.J., Siskind, D.J., Whiteford, H.A., Harris, M.G., 2017. A systematic review and meta-regression of the prevalence and incidence of perinatal depression. J. Affect. Disord. 219, 86–92. doi:10.1016/j.jad.2017.05.003.

World Health Organization, 2013. Mental health action plan 2013–2020. World Health Organization Retrieved 5 September from.

Wright, B., Barry, M., Hughes, E., Trépel, D., Ali, S., Allgar, V., Cottrill, L., Duffy, S., Fell, J., Glanville, J., Glaser, D., Hackney, L., Manea, L., McMillan, D., Palmer, S., Prior, V., Whitton, C., Perry, A., Gilbody, S., 2015. Clinical effectiveness and cost-effectiveness of parenting interventions for children with severe attachment problems: a systematic review and meta-analysis. Health Technol. Assess 19 (52), 1–347. doi:10.3310/hta19520, vii-xxviii.

Zhou, C., Hu, H., Wang, C., Zhu, Z., Feng, G., Xue, J., Yang, Z., 2020. The effectiveness of mHealth interventions on postpartum depression: a systematic review and meta-analysis. J. Telemed. Telecare. doi:10.1177/1357633x20917816, 1357633x20917816.